Climate risks to essential commodities:

What business leaders need to know

Special report for Asia Pacific Economic Cooperation economies

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Executive Summary

Companies depend on six essential commodities: lithium, cobalt, copper, iron, zinc, and aluminium. It's not just manufacturing or industrial companies that rely on them. These commodities are critical inputs for technology, energy systems, electronics, transport, construction, infrastructure, consumer products, and more.

As we explain in this report, production of these six commodities may be increasingly disrupted by accelerating climate change.[1] Even modest declines in commodity production can cascade through supply chains, affecting prices and availability.[2] Therefore, business leaders should be aware of climate-driven threats to supplies of essential commodities and take steps to protect their operations.

Building on our earlier work that identified severe climate risks to global production of many essential commodities, this report drills down to climate risks to commodity production in selected economies (US, Canada, China, Australia, Peru, Chile, Mexico) that are part of the Asia Pacific Economic Cooperation group (APEC) as a special report for the global APEC CEO Summit in November 2024.

APEC economies are leading producers of all six commodities. In the cases of lithium, copper, and zinc, the world's top 3 producers are all APEC economies. As a result, climate-driven disruption to commodity production in APEC economies could have significant impacts on supply chains across the world.

We examine two impacts of climate change known to be detrimental to production of these commodities: heat stress which can make it too hot for workers to work outside, and drought which can be problematic because mining and processing these commodities often requires a lot of water.

The goal of this report is to encourage business leaders - both producers and consumers of these commodities - to understand growing climate risks and subsequently take steps to manage these risks and build resilient supply chains. The report's final chapter, 'Urgent actions for Business,' offers a range of practical steps business leaders can take illustrated by case studies from across the world.

Key findings:

- **The world relies on APEC economies for six essential commodities.** APEC economies including Australia, China, Peru, Chile and Canada are among the world's top three producers of all six commodities in our study. In the cases of lithium, copper and zinc, the world's top 3 producers are *all* APEC economies.
- **Copper mines in Chile and Peru, the world's #1 and #2 copper producers, face steeply rising drought risks even in an optimistic scenario in which the world sharply reduces carbon emissions.** In this optimistic scenario, 41% of Peru's copper production will be exposed to significant drought risk by 2050, up from 0% today. Similarly, drought risk to Chilean copper production more than triples by 2050.
- **Lithium mines in Australia and China, the world's #1 and #3 lithium producers, face huge increases in drought risks even if carbon emissions rapidly decline.** 68% of Australia's lithium production and 70% of China's will be exposed to significant drought risk by 2050, up from 0% in both countries today.
- **Australia is the world's #1 producer of iron and bauxite, and #2 producer of zinc and cobalt. Australian production of all these commodities faces steep rises in drought, heat stress, or both.** For example, by 2050 in a high emissions scenario, 46% of Australian bauxite production faces levels of heat and humidity that are dangerous to outdoor workers (up from 0% today).
- **Future emissions reductions will not protect businesses from a changing climate.** Even in an optimistic low emissions scenario, many commodities will see rising levels of risk from heat stress and drought, highlighting the importance of adapting to a changing climate while we strive to reduce carbon emissions to prevent climate change from becoming even more severe.
- **In some cases, risks are rising sharply from low levels, underlining the need for business leaders to prepare to manage increasing risks** that, in some cases, they may have little experience in managing.
- **What this means for business leaders: take three steps to prepare for the growing risks of disruption.** First, enhance resilience by identifying and managing climate risks throughout the supply chain. Next, capitalise on the opportunities to deliver products, services, or business models that help companies and communities become more resilient and adapt to the changing climate. Finally, join forces with stakeholders from governments to communities to shape collaborative outcomes and enhance adaptation at a policy and systemic level. We offer examples and case studies in the 'Urgent actions for business' chapter.

Chapter 1:
Climate risks to commodity production in APEC economies

The world relies on APEC economies' production of six essential commodities

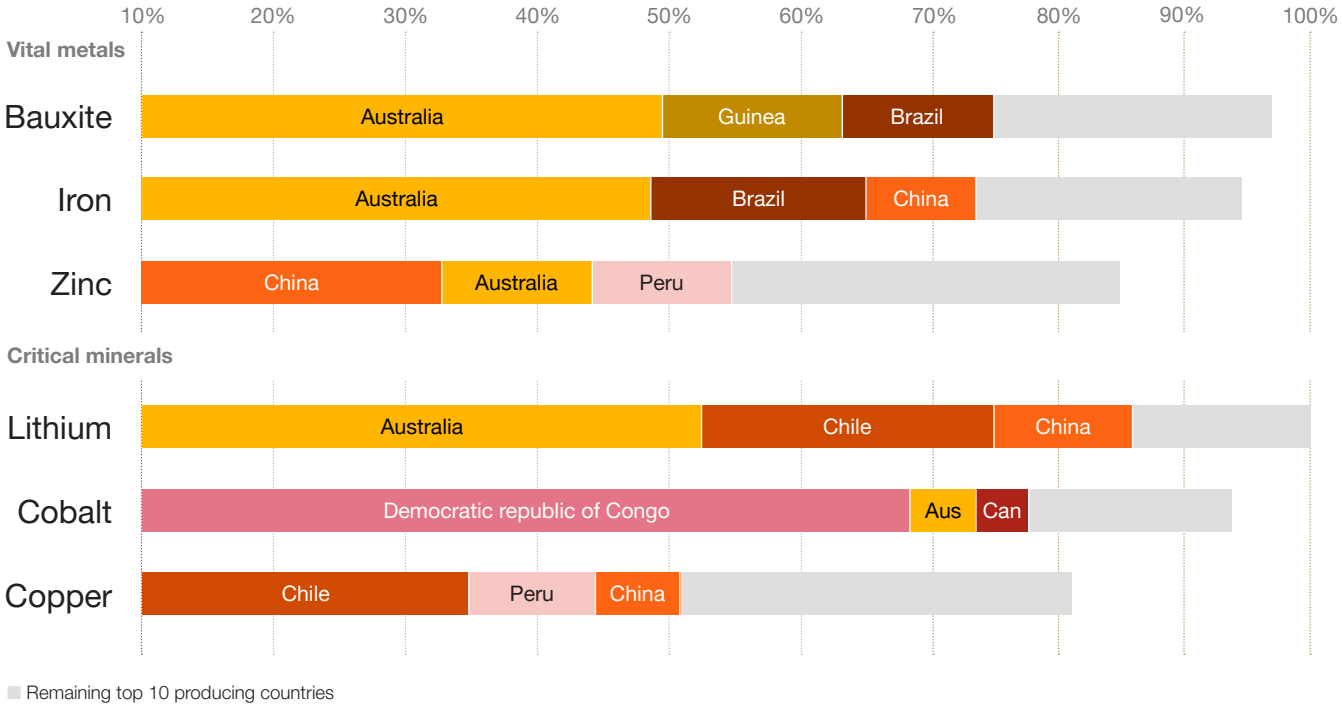
Six commodities are essential to the global economy:

- **Three critical minerals:** cobalt, copper, and lithium that are integral to electronics, technology, energy systems, and a successful transition to a low carbon economy.
- **Three vital metals:** iron, aluminium, and zinc that are widely used in manufacturing, transport, infrastructure, construction, consumer products, and more.[4]

From Australia's lithium mines to Chile's copper mines, APEC economies are some of the world's largest producers of these essential commodities. APEC economies including Australia, China, Peru, Chile and Canada are among the world's top three producers of all six commodities in our study.

In the cases of lithium, copper and zinc, the world's top 3 producers are *all* APEC economies.

APEC economies are leading producers of six essential commodities
Share of global production (2020)



Source: CapIQ, FAO, PwC analysis

We analyse climate risks to production of selected commodities in seven APEC economies: Australia, US, China, Peru, Chile, Canada and Mexico

Here is how we chose which economies and commodities to include. We examine an APEC economy's production of a given commodity if:

- The country produces at least 1,000 metric tons of the commodity each year.
- A minimum of four different mine owning companies produce the commodity in the country. Our goal is discussing risks at a national level, not identifying risks for individual producers. So we do not discuss climate risks for commodities that have three or fewer producers in a given country. That is why this report does not include climate risks to lithium production in Chile or cobalt production in Canada. There are too few producers.

Following these criteria, we are able to analyse climate risks to selected commodities in seven APEC economies.

We located mines in APEC economies, and then identified how much each location will be increasingly affected by heat stress and drought

To carry out the climate risk analysis, we located the mines that produce these commodities in APEC economies. We noted the amount of the commodity that each mine produces. Next, we analysed the degree to which each mine will increasingly be subject to two climate impacts known to be detrimental to production: heat stress and drought. Heat stress can make it difficult or even life-threatening for workers to work outside. Drought can harm mining which can be heavily dependent on water (for example, it can take thousands of litres of water to produce one kilogram of lithium).[5]

We class drought and heat stress risks as significant, high or extreme.

Drought Risk Levels

Risk Category	Risk Levels / Duration of Severe Drought
Significant	**20% of time** in severe drought, over the 20 year span centred on each year being analysed
High	**40% of time** in severe drought, over the 20 year span centred on each year being analysed
Extreme	**80% of time** in severe drought, over the 20 year span centred on each year being analysed

Note: The term significant as we use it here has no relationship to statistical significance testing.
Severe drought: Defined as values below -1.5 on the Standardised Precipitation-Evapotranspiration Index, a multiscalar drought index.

Heat stress Risk Levels

Risk Category	Risk Levels / Duration	Impact
Significant	At least 10 days per year with an average daily WBGT of 26.3°C. Total days with WBGT at this level may be higher.	**Reduces labour productivity by at least 25%**
High	At least 10 days per year with an average daily WBGT of 28.9°C. Total days with WBGT at this level may be higher.	**Reduces labour productivity by at least 50%**
Extreme	Each year, an average daily WBGT of 32.2°C occurs on one or more days.	**Reduces labour productivity by at least 75%** and is dangerous to outdoor workers.

Source for labour productivity impact: Rockefeller Foundation Resilience Center, 'Extreme heat: Economic and social consequences for the US," 2021
WBGT = Wet Bulb Globe Temperature, a measure of heat and humidity

Our analysis reveals the proportion of APEC commodity production that will be exposed to significant, high or extreme levels of heat stress and drought risk at current locations of production.[6]

We reveal how climate risks change in both low and high emissions scenarios

We identify climate risks at the present day (based on 2020), in 2035, and in 2050. We demonstrate how climate risks will vary according to how much progress the world makes in reducing emissions using these two scenarios defined by the UN's Intergovernmental Panel on Climate Change:

- **A low-emissions scenario** in which substantive action is taken to curb emissions, keeping global average temperature increase below 2°C (Scenario SSP1-2.6).
- **A high-emissions scenario** in which no action is taken to follow a low-emissions pathway, resulting in a catastrophic rise in global average temperature of 4.4°C by 2100 (Scenario SSP5-8.5).

We analyse low and high emissions scenarios for the latest year in our analysis, 2050, because as time passes the effects of divergent paths become more apparent. For more information on our methodology, please see our earlier report on climate risk to global commodity production.

Our analysis provides insight for businesses seeking to protect their operations (and policymakers seeking to protect their economies) from accelerating climate change.

Assumptions and limitations

- **We assume production levels and locations remain the same.** We do not seek to predict how the locations and volumes of commodity production will change in the future. Therefore, we use today's locations and volumes of commodity production in our analysis. This approach allows us to forecast how today's APEC-based commodity production may be increasingly affected by climate change.
- **Our analysis reveals risk exposures, not actual disruptions to supply.** We estimate the share of total supply that could be exposed to significant, high, or extreme levels of heat stress or drought. We do not quantify the potential disruption, such as how much production volumes could fall. Commodity producers could take action to protect their operations from climate disruption, and they would be wise to do so.

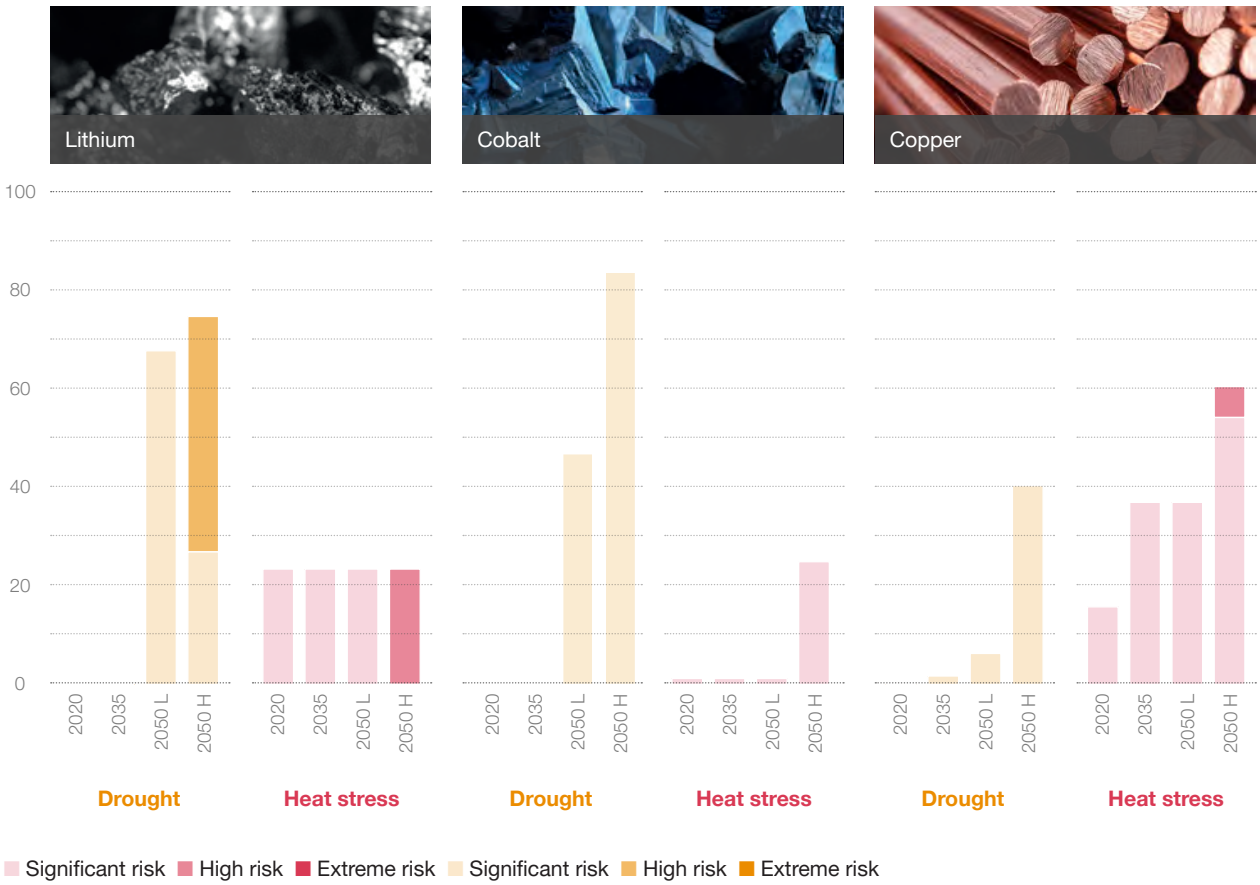
Below we summarise the results of our analysis and some of the lessons these offer for commodity producers and consumers.

Australia and China face increases in climate risk to all commodities analysed

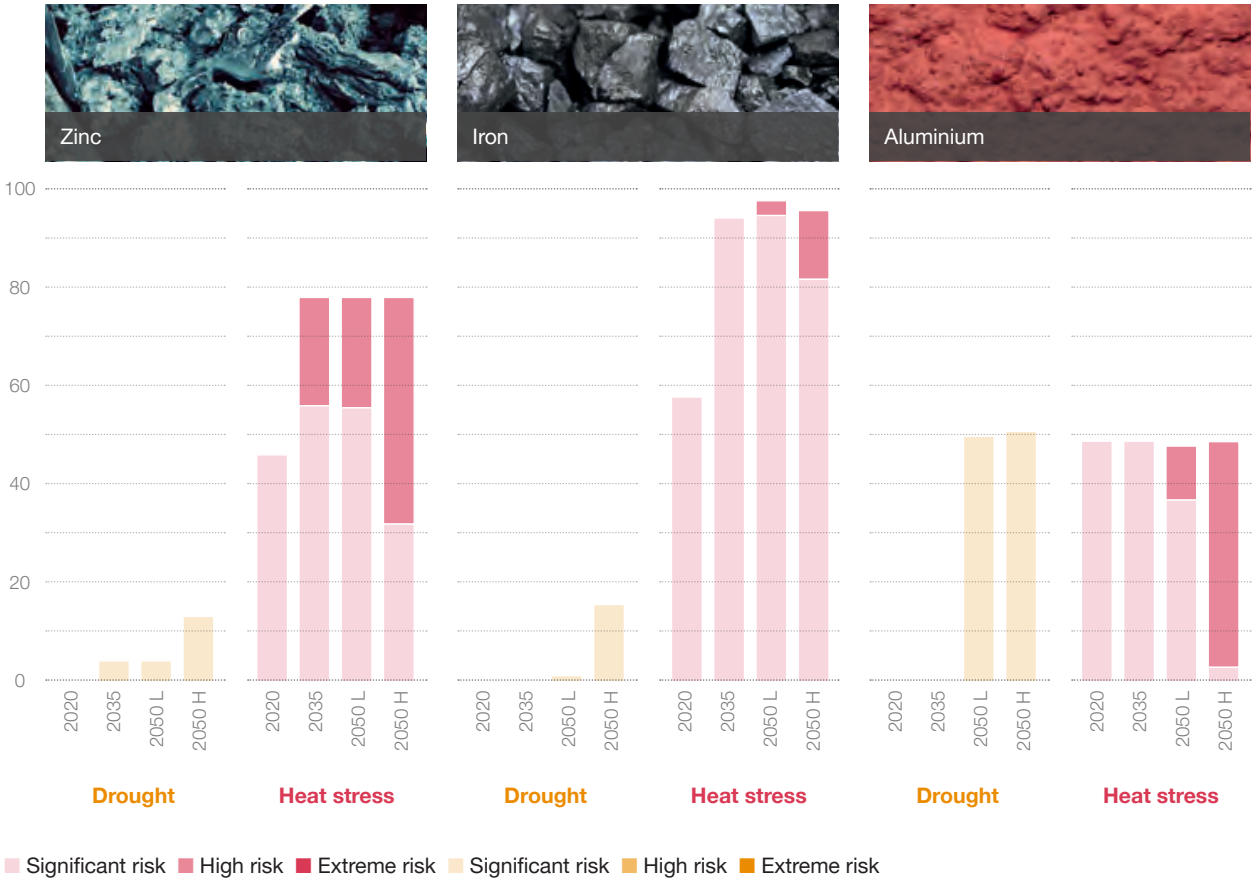
Australia's production of all six commodities faces growing risks of heat stress, drought, or both. In the case of drought, risks are rising from very low levels which may mean that mining companies are less accustomed to managing these risks. Today, none of the six commodities produced in Australia face a significant level of drought risk (as we define significant), but by 2050 all six commodities will face some degree of significant drought risk - even under an optimistic low emissions scenario.

Perhaps the most extreme case is that of lithium (Australia is the world's #1 lithium producer). None of Australia's lithium production faces significant drought risk today, but this rises to 68% by 2050 even in an optimistic low emissions scenario (in other words, 68% of Australia's lithium would be produced at mines that face significant drought risk).

Australia: Commodity production at risk



Source: Protecting People and Prosperity

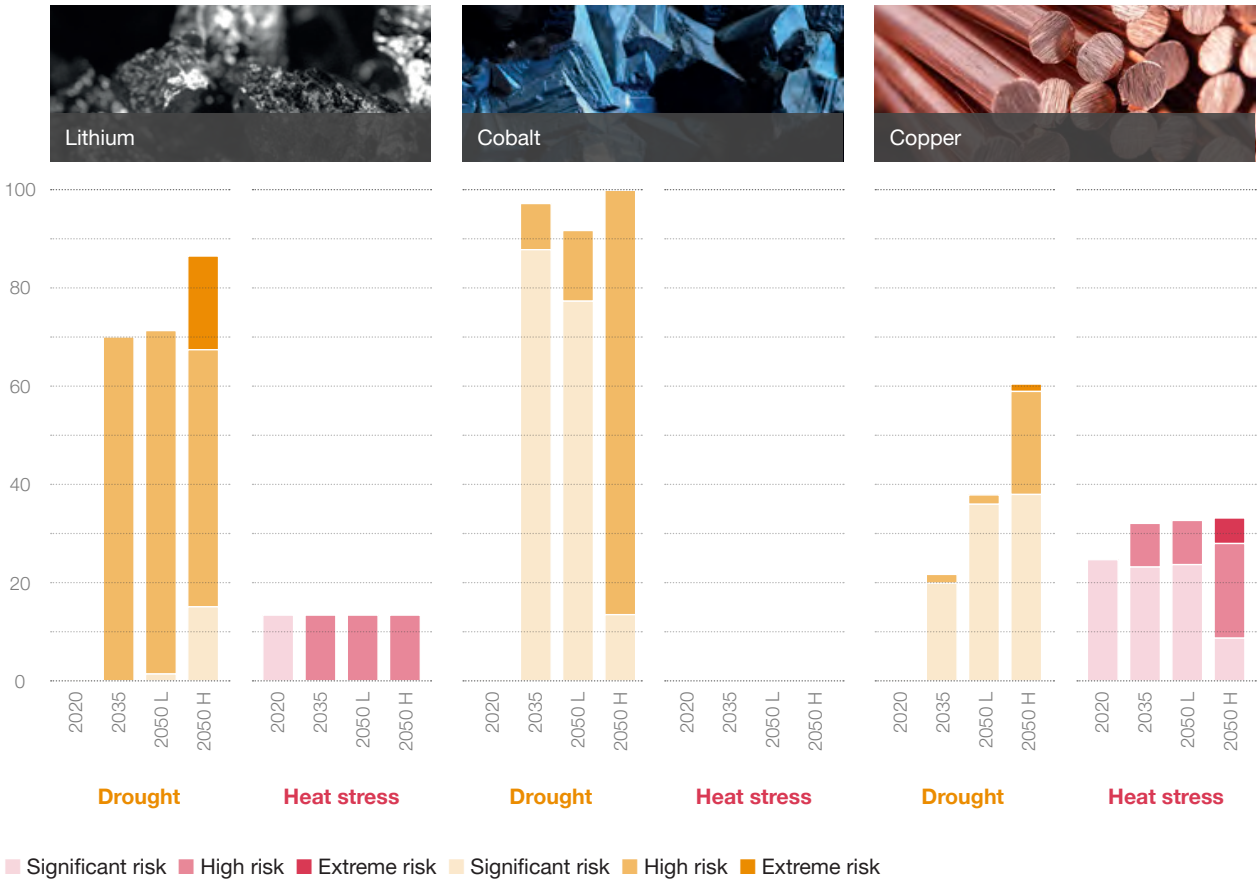


Source: Protecting People and Prosperity

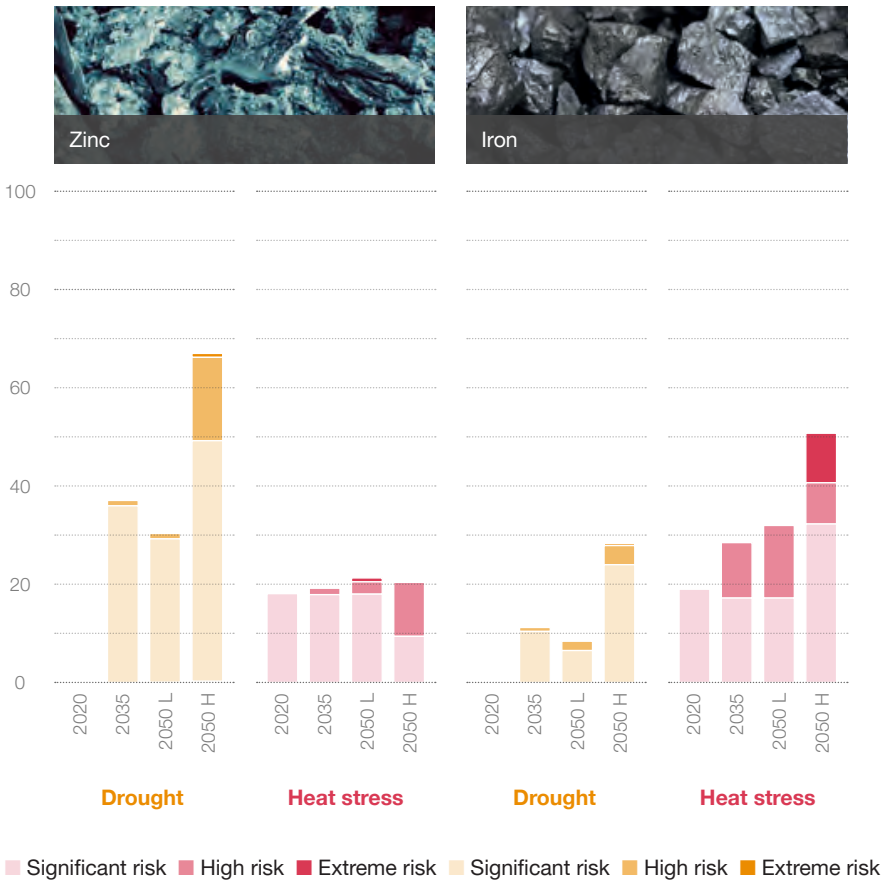
Charts show the % of Australia's total volume of production of a given commodity that is at risk (not the % of Australian mines at risk).

China's commodity production faces particularly steep increases in drought risk. All commodities that we analysed for China face rising drought risks - including the commodities for which China is one of the world's top three producers: lithium, copper, and iron. For example, the proportion of Chinese lithium production facing significant or higher drought risk rises from 0% today to 70% as soon as 2035.

China: Commodity production at risk



Source: Protecting People and Prosperity

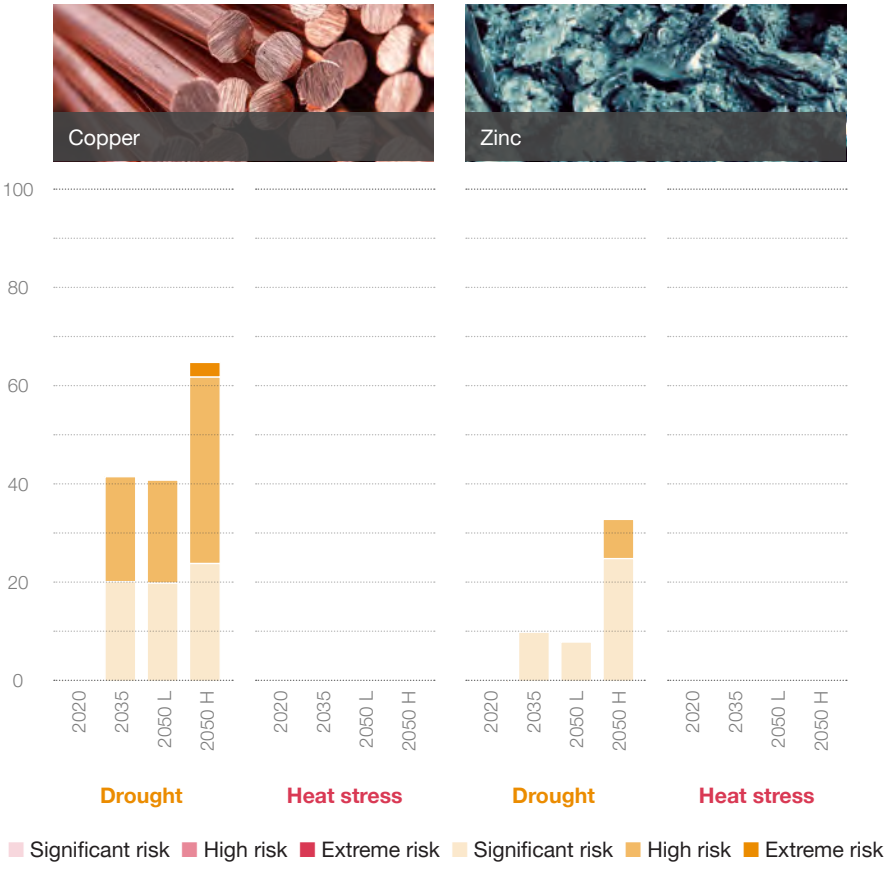


Source: Protecting People and Prosperity

Peru, Canada, US and Mexico face new and unprecedented levels of drought risk

Peru is among the world's top three producers of copper and zinc. Our analysis shows no increase in heat stress risk to Peru's copper and zinc production (as we define heat stress risk), but sizable increases in drought risk. 41% of Peru's copper production and 10% of its zinc production could be exposed to significant or higher drought risk as soon as 2035 - up from 0% of each commodity today.

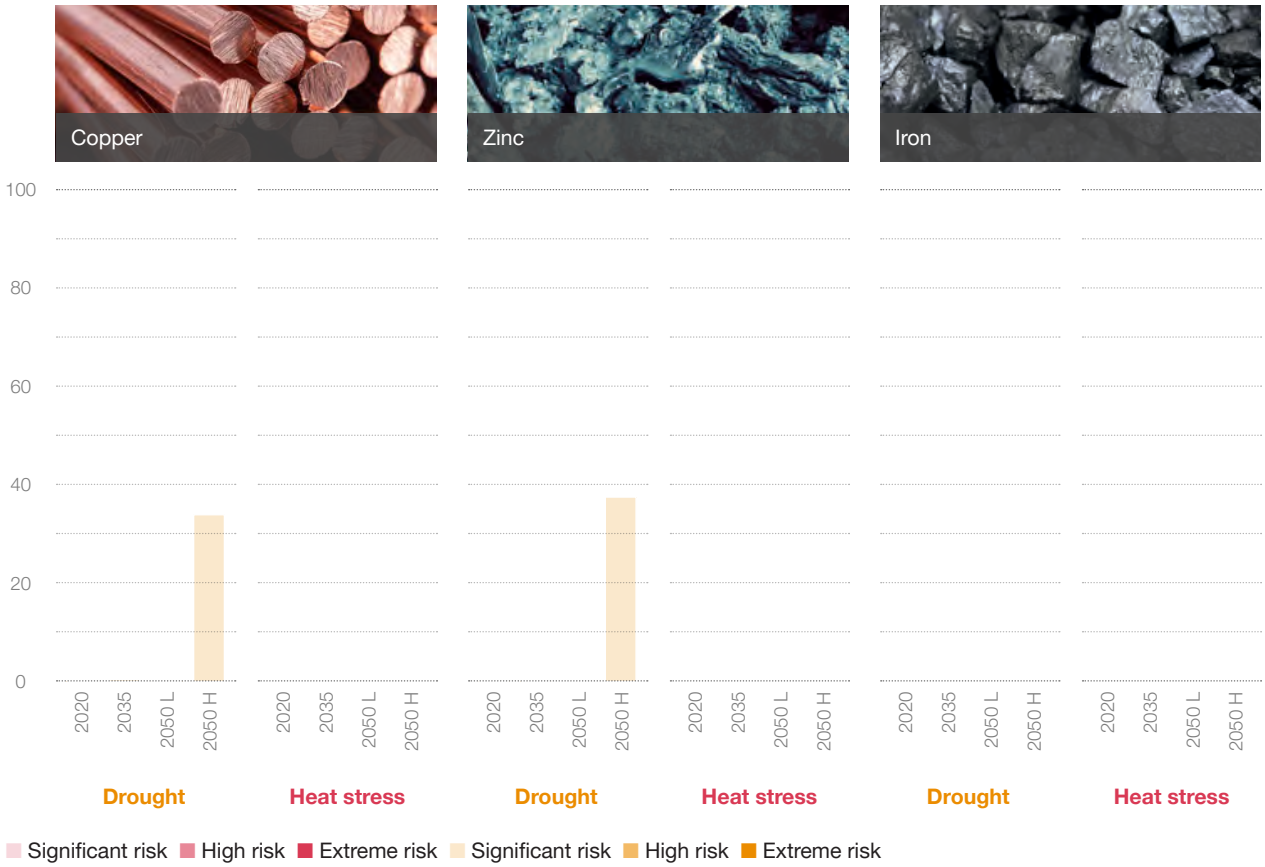
Peru: Commodity production at risk



Source: Protecting People and Prosperity

Canada, similarly, faces no increase in heat stress risk (as we define heat stress risk) but notable rises in drought risk. 34% of Canada's copper production and 38% of its zinc production faces significant drought risk by 2050 in a high emissions scenario - up from 0% today.

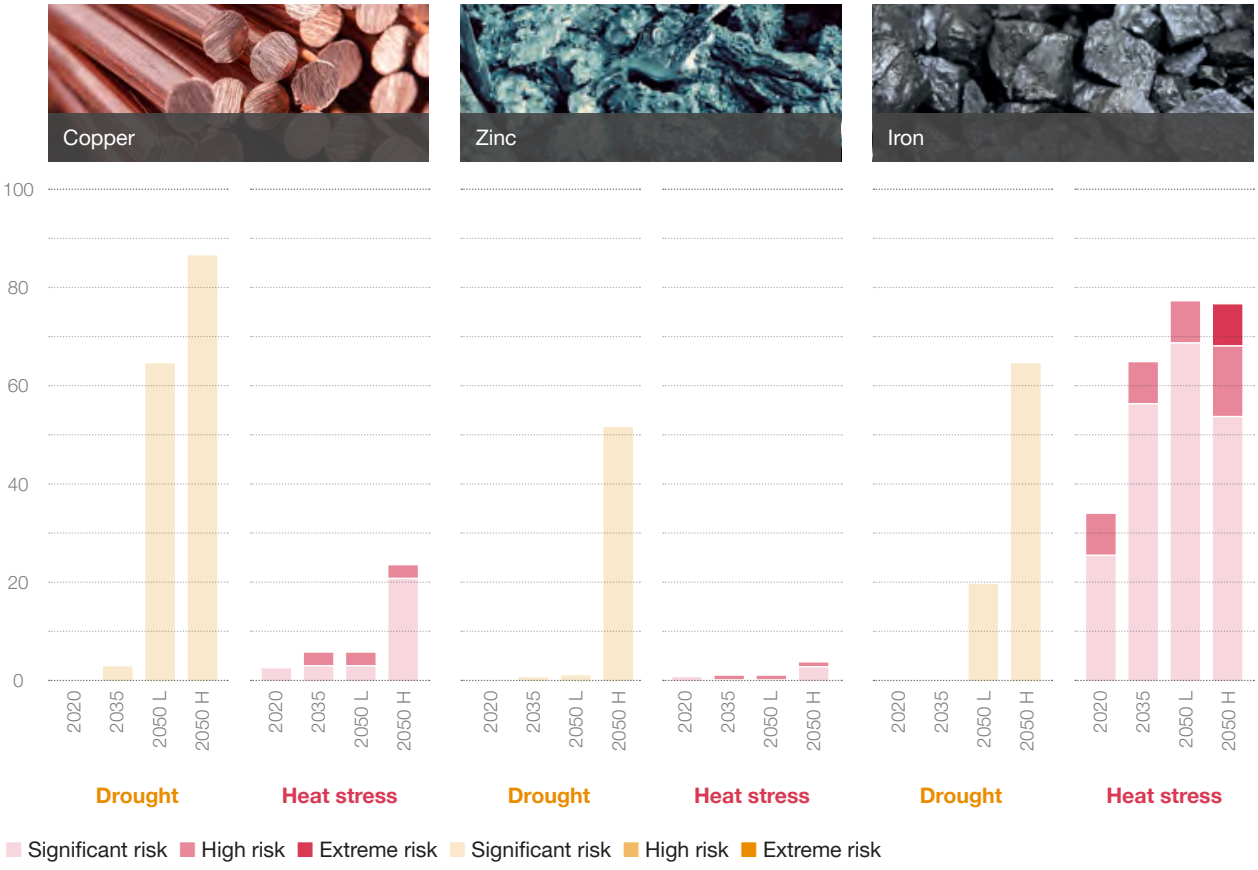
Canada: Commodity production at risk



Source: Protecting People and Prosperity

Mexico, too, faces unprecedented levels of drought risk which is set to rise sharply from near-zero today. By 2050, in a high emissions scenario, 52% of Mexico's zinc, 65% of its iron, and 87% of its copper production could face significant drought risk, up from 0% today. In addition, heat stress risk to Mexico's iron production more than doubles by 2035.

Mexico: Commodity production at risk

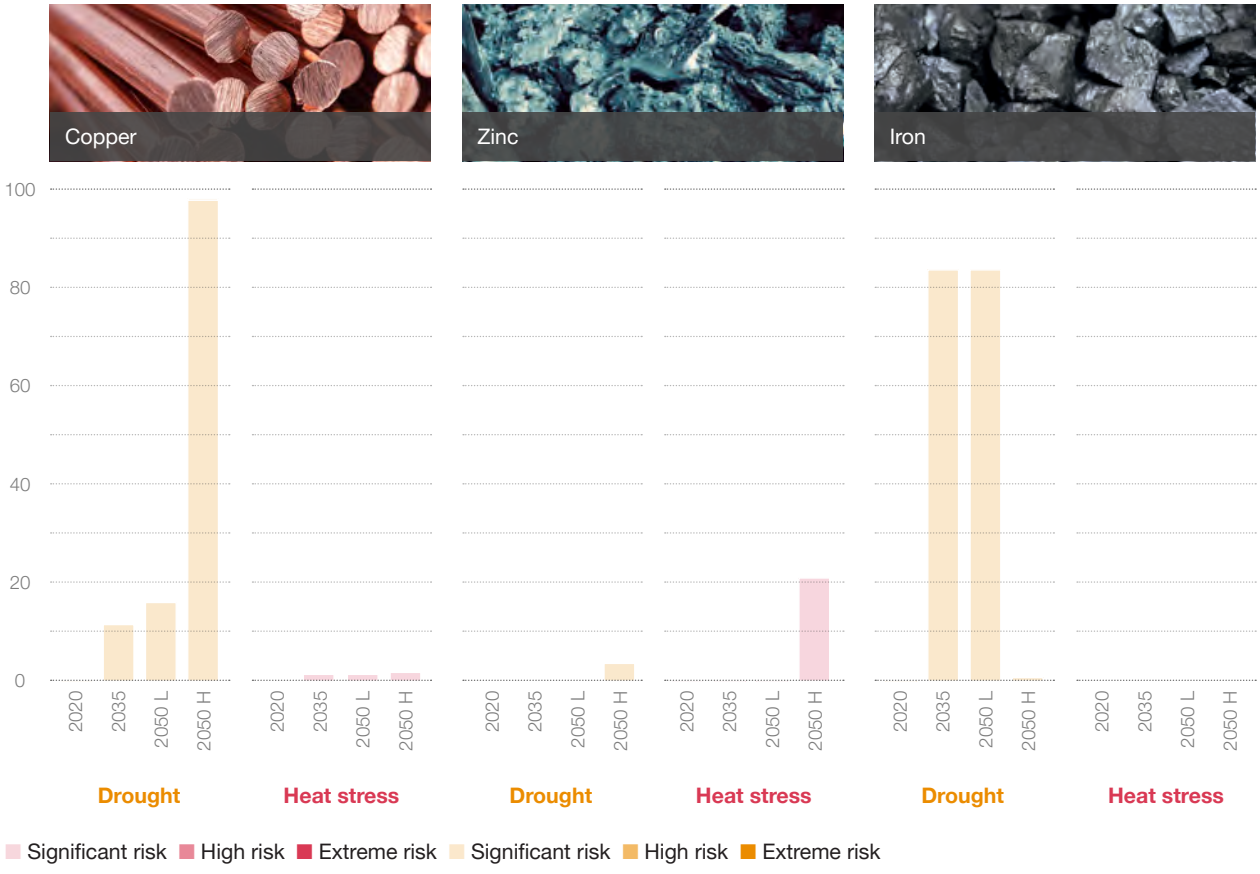


Source: Protecting People and Prosperity

While US zinc sees small rises in drought risk in the coming years, drought risk to US copper rises from near-zero today to 98% of copper production at high drought risk in a 2050 high emissions scenario. Significant drought risk to US iron production rises from 0% of production at risk today to 83% at risk as soon as 2035 (though, as we will see below, this drought risk could decline after 2035 in a high emissions scenario because as climate change gets more severe it may tend to cause increased precipitation).

Some readers may be surprised by the low levels of heat stress risk shown for US commodities. For example, US copper is mined in states like Arizona, Nevada, and New Mexico that frequently experience high temperatures. In this report, we use a heat stress metric that captures the combined effects of temperature and humidity (wet bulb globe temperature). As these states are relatively arid, their risk of heat stress as we define it is low. That does not mean, however, that high temperatures are not an issue in these locations.

US: Commodity production at risk



Source: Protecting People and Prosperity

The case of US iron demonstrates that climate risks mostly increase - but can sometimes decrease

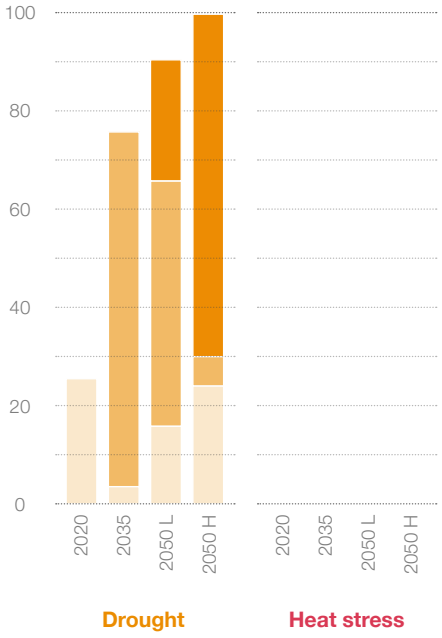
Look closely at our risk projections for US iron and a puzzling fact emerges. Drought risk to US iron is actually lower in a 2050 high emissions scenario than in a 2050 low emissions one. The reason is that much US iron is produced in the Great Lakes region which could see increased precipitation as climate change worsens.[7] The case of US iron is a reminder that climate change can decrease as well as increase the risks of certain hazards.[8]

Chile faces rising drought risks - and shows how some producers are adapting

The message of this report is that commodity producers should prepare to adapt to a warming climate. Chile offers one example of how to do so.

Chile is the world's largest producer of copper, mining over 5 million tons a year. As soon as 2035, 72% of Chile's copper production faces high drought risk. In response to worsening droughts in Chile, some mining companies are increasing the use of desalinated seawater in their operations. Today there are more than 20 desalination plants operating in Chile with 10 more expected to come online by 2025.[9]

Chile: Commodity production at risk



A note on lithium: Chile is also a major producer of lithium. We do not discuss risks to Chilean lithium production in this report because Chile has very few lithium mining companies. Our goal in this report is discussing risks at a national level, not risks to individual companies. Therefore, we confine ourselves to discussing risks to commodities produced by at least four different companies in a given country.

Source: Protecting People and Prosperity

Conclusions

Our analysis leads us to the following conclusions:

- **Future emissions reductions will not protect businesses from a changing climate.** Even in an optimistic low emissions scenario, commodities will see rising levels of risk from heat stress and drought, highlighting the importance of adapting to a changing climate while we strive to reduce carbon emissions.
- **In some cases, risks are rising sharply from low levels, underlining the need for commodity producers and consumers to prepare to manage increasing risks** that, in some cases, they may have little experience in managing.

Chapter 2:
Urgent actions for business

Three steps to adapt to a changing climate

Businesses - both commodity producers and consumers - should act with urgency to protect their operations and build resilient supply chains. How can companies take action to protect their operations, people, and supply chains from the effects of climate change? Below, we explore three steps businesses can take to prepare their business for what lies ahead: 1. Enhance resilience by identifying and managing risks, 2. Capitalise on opportunities and 3. Shape collaborative outcomes.

Business case	**Avoid economic losses**	**Increase revenue, cost savings and sustainability**	**Protect communities and ecosystems**
Pillars	**Enhance resilience**	**Capitalise on opportunities**	**Shape collaborative outcomes**
Core actions	Assess the impacts of climate risks on business and act to adapt and build resilience	Leverage products, services and business models that help businesses, communities and ecosystems adapt to and build resilience	Participate in multistakeholder efforts that promote action on climate change adaptation
	Work with suppliers and communities connected to the value chain to enhance business resilience	Pursue adaptation opportunities that contribute to efficiency, sustainabiity and climate change mitigation	Deliver transformative projects to build community and ecosystem resilience
Enabling actions	Establish a climate strategy that integrates climate change adaptation and net-zero transformation		
	Mainstream climate risk considerations into business decision-making		
	Make comprehensive and transparent climate disclosures		

These three steps come from a framework that PwC developed with the World Economic Forum (WEF) to accelerate business action on climate change adaptation. Below we share selected case studies of companies that have successfully applied these steps. For a more extensive set of case studies, we invite readers to visit our earlier report on global risks to commodity production in all economies.

Case study: Tesla's strategy to protect its supply of critical minerals

Tesla is one of the largest manufacturers of electric vehicles in the world and relies on regular supplies of lithium and cobalt to make the batteries for its cars. Both lithium and cobalt play an essential function in improving vehicle range and safety performance.

The company has therefore adopted a multi-pronged strategy to build vertical integration and help it establish a reliable lithium supply chain. It is currently building its own lithium refinery in Texas and has signed agreements with lithium and nickel producers in the United States and Canada to grow its supplier base. It is also collaborating with other battery makers to facilitate consistent supply. In addition to its own cell manufacturing operations, the company currently uses cells from four different suppliers with three different battery chemistries.

Tesla conducts an annual Enterprise Risk Assessment to identify physical climate-related risks to the business including site-specific reviews of its gigafactories and other manufacturing sites. Using the results from these analyses, Tesla is looking at ways to protect its manufacturing activities against medium-term and long-term climate impacts. Learn more

Case study: Molson Coors supports local farmers to grow climate-resilient barley

US brewer Molson Coors has developed an industry-leading barley program that produces all the barley it needs for its US production and 20% of the barley for its Canadian operations.

The program was created in 1946 and has grown to encompass more than 800 farmers across 200,000 acres in prime barley-growing regions in four US states, providing the brewer with consistently high-yield, high quality barley. The program incorporates the knowledge of a team of researchers based in Idaho who crossbreed variants of barley, developing new ones that can withstand growing conditions that have become harsher over the last few decades. Farmers are also supported by a team of seven Molson Coors agronomists who consult on growing conditions and help them implement best practices in terms of water efficiency, soil health, pest control and more.

The barley program increasingly incorporates technology that makes growers more efficient, including mapping and data collection using drones and satellite imagery, tools to measure water content in soil and precision planting equipment.

As a result, farms are able to adapt their agricultural practices to account for unpredictable weather patterns, drought and poor soil. The result is a win-win, with the program providing stability for the farmers, many of them family-owned operations who have worked with Molson Coors for decades, and consistently high quality barley for the business.

Case study: Chilean mines are combating water scarcity with desalination plants - and now Direct Lithium Extraction (DLE)

Chilean mines in 2020 produced 154,000 tons of lithium, equal to 25% of the global total. However our analysis shows that by 2025, many face a high risk of drought. In addition, intensive water use by Chilean mines has increased water stress in some local communities. In anticipation of rising drought risk, several mining companies in Chile have invested in desalination plants. There are 22 such plants currently in operation in Chile, with plans for a further nine.

Strategic investment in desalination has enabled Chilean mines to prepare for rising risk exposures and has supported production at scale in drought prone regions. Building a large desalination plant is a costly solution but investment may create a competitive edge in the longer term.

In addition, Direct Lithium Extraction (DLE) has emerged as a game-changing technology, offering a more efficient, environmentally friendly, and cost-effective solution to extracting lithium. Unlike conventional methods, which rely on evaporation and mineral concentration, DLE involves the selective extraction of lithium ions directly from lithium-rich solutions. This method, which has been incorporated into Chile's national lithium strategy, bypasses the need for evaporation ponds, allowing for faster extraction rates, reduced water consumption, and minimized environmental impact.

Case study: PwC helped Mosaic manage climate change risks to its operations

Mosaic is a leading producer of concentrated phosphate and potash and wanted to better understand how physical climate change risks could potentially impact its global operations. PwC US's team of climate risk specialists began by undertaking a broad qualitative risk assessment that outlined some of the most important potential climate-related risks to Mosaic's operations. Using future climate scenarios from a variety of established models and third party expert data sources, they then evaluated the potential business impact of each risk.

Together, Mosaic and PwC identified some of the highest-priority climate-related risks across the business, ranked by estimated likelihood of occurrence and severity of impact. Following this initial workshop, Mosaic identified four physical risks to study further. PwC analysed potential risk levels and associated business impacts of the largest physical risks to Mosaic. It leveraged 2ºC and 4ºC warming scenarios to examine the potential risks to the business under both a low-carbon economy and a high-emissions scenario, creating a risk spectrum for the company's assets. PwC then integrated Mosaic's future plans and mitigation efforts to give increased focus to the analysis.

The exercise helped Mosaic refine its estimates of the potential impacts that certain physical risks could have on its global operations. It will also enable it to make more informed decisions in the future.

Case study: Nestle's climate resilience strategy

Nestlé, a global food and beverage company, undertook climate change risk assessments at the site, project and supplier levels. Having identified climate change as a key risk, the company used these assessments to better understand and manage climate-related risks and opportunities. It also used climate scenario analysis to better understand the impact of climate change over long time horizons.

Nestlé simulated physical climate risk for the period 2025 to 2040. The analysis considered a temperature rise beyond the 1.5°C target by 2040 to analyse impacts on direct operations due to damage to facilities and production issues due to input supply shocks. Informed by the climate risk assessment and scenario analysis, Nestlé developed a comprehensive climate strategy outlining its efforts to mitigate the physical risks of climate change to its business. The company also developed site-specific loss prevention, business continuity and water reduction strategies as measures to manage risks to facilities. It promoted sustainable sourcing, including promoting regenerative agriculture in the value chain. This climate strategy has been integrated into Nestlé's existing systems and processes, including risk management and executive compensation. It is implementing the adaptation measures identified under the strategy across all geographies and markets where the company operates. Learn more.

Recycling can help to protect commodity users from climate risks to mines by reducing dependence on newly mined commodities. For instance, recycling 1 ton of steel in the US conserves 1.1 tons of iron ore, the raw material that makes steel. There has been a notable increase in the past few years in lithium-ion battery recycling, which reduces the need for freshly mined lithium.[34] Apple is one of several major companies which has been exploring their ability to increase the role of recycling in their supply chain:

Case study: Apple drives efforts to reduce its reliance on mining

Technology giant Apple is stepping up its efforts to reduce its reliance on mining with a new focus on using recycled or renewable materials in its products. At present around 20% of the materials used to make its products are from recycled or renewable sources, but by 2025 it plans to use 100% recycled cobalt in all its batteries, 100% recycled tin and gold plating in all its printed circuit boards, and 100% recycled rare earth elements in all magnets used in its products. This will reduce its reliance on mining, smelting and refining, with the long term aim of increasingly reducing its reliance on the mining of new materials.

The company is also collaborating with other businesses and organisations on an industry level by engaging in industry initiatives such as the Responsible Minerals Initiative (RMI) and the Platform for Accelerating the Circular Economy (PACE), a global collaboration platform for public and private decisions makers to share best practises towards a circular economy.[10]

Endnotes

1. Climate change increases the risk of a variety of perils from flooding to hurricanes. In this report, we focus on two perils known to be detrimental to mining production: heat stress and drought.
2. European Central Bank, Supply chain disruptions and the effects on the global economy.'; White House, 'Issue Brief: Supply Chain Resilience.'; World Bank 'Global Supply Chain Stress Index.'
3. 'Expansion of Desalination Plants in the Face of Drought in Chile – How Mining is Forcibly Adapting' - Intellisense
4. The US government recognises lithium, cobalt, copper, zinc, and aluminium as critical materials. (Energy.gov 'What are critical minerals and materials?')
5. Academic research finds that climate change has already reduced the growth of overall global agricultural productivity by between 30 and 35 percent.
6. For more information on our methodology and how we calculate levels of heat stress and drought risk, please see the Methodology Appendices in the first report in this series.
7. Climate change often influences precipitation patterns so that "dry gets drier, and wet gets wetter."
8. NOAA (2016) U.S. Climate Resilience Toolkit: Great Lakes - link
9. 'Expansion of Desalination Plants in the Face of Drought in Chile – How Mining is Forcibly Adapting' - Intellisense
10. Apple Environmental report - link

Acknowledgements

PwC would like to thank the following for their analysis and expertise:

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